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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WASHINGTON 25, D. C.

PROGRESS REPORT

BADGER WASH COOPERATIVE STUDY
PRECIPITATION, RUNOFF, AND SEDIMENT YIELD, 1968 SEASON

By

Gregg C. Lusby, Research Hydrologist

WATERSHED COVER AND FORAGE UTILIZATION 1968-1969

By

J. Robert Owen, Research Hydrologist

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U.S. Geological Survey
Progress Report
Badger Wash Cooperative Study
Precipitation, Runoff, and Sediment Yield, 1968 Season
by Gregg C. Lusby

Shown in the following tables are data on precipitation, runoff, and sediment yield obtained at the Badger Wash study area during 1968. A complete description of the study area and instrumentation installed may be obtained from USGS Water-Supply Paper 1532-B.

Precipitation amounts are shown in table 1. Average precipitation for the summer season as measured in 12 rain gages was 7.72 inches, which is 2.99 inches, or 63 percent, more than the average for the previous 14 years. The largest storms of the year occurred in July and August.

Runoff and sediment yield from all watersheds is shown in table 2 and runoff from paired watersheds is shown in table 3. Some of the largest amounts measured during the period of record occurred during the summer. Several large storms in July and August produced most of the runoff and sediment.

The furrowed area in drainage basin 16 produced about one-third the water and one-half the sediment as the adjacent unfurrowed area.

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[When numbers are records.]

Date		Watershed number							
		1	2	3	2B*	3A	3B	4A**	4B**
Apr.	2	(0.20)	(0.20)	(0.20)	0.20	0.18	0.19	0.22	0.21
	3	.13	.14	.17	.15	.13	.14	.16	.17
	6	.50	.53	.48	.48	.49	.50	.47	.48
	16	.20	.18	.20	.16	.21	.20	.14	.13
	17	.19	.20	.09	.16	.20	.21	.14	.16
	18	.13	.14	.12	.12	.11	.11	.12	.11
	19	.18	.20	.16	.19	.19	.21	.20	.19
	21	0	0	0	0	0	0	0	0
	26	.07	.08	.02	.04	.03	.04	.04	.04
	27	.02	.03	.04	.03	.04	.03	.02	.02
May	5	.03	.10	.05	.06	.05	.05	.05	.05
	6	.09	.14	.12	.10	.08	.09	.11	.11
	11	.02	.03	0	0	.04	.04	.03	.02
	12	.20	.23	.24	.23	.21	.21	.24	.26
	13	.11	.16	.16	.14	.18	.20	.27	.28
	24	.05	.07	.05	.05	.10	.10	.20	.20
June	7	.11	.12	.06	.08	.07	.07	.09	.09
July	5	0	.04	(.04)	.04	.05	.04	.07	.08
	22	0	0	0	.01	0	0	.02	.02
	23	0	.02	0	.05	0	0	.01	.01
	24	.05	.06	.11	.04	.05	.05	.08	.09
	25	0	0	0	.02	0	0	.01	.01
	26	1.51	1.53	1.49	1.20	1.39	1.36	1.12	1.12
	27	1.05	.90	.71	.80	.98	.91	.50	.53
	30	0	.08	0	.03	0	0	.02	.02
Aug.	2	.85	.81	.93	1.04	.74	.76	.95	.96
	7	.16	.22	.14	.28	.07	.08	.16	.17
	9	.10	.10	.15	.15	.07	.09	.08	.10
	13	.34	.40	(.25)	.30	.16	.17	.22	.21
	14	.91	1.05	(.70)	.80	.88	.89	.87	.88
	15	0	0	0	.01	0	0	0	0
	17	0	0	0	0	0	0	.01	.01
	22	.02	0	0	.02	0	0	.02	.02
	28	.11	.16	(.50)	.61	.12	.14	.30	.31
Sept.	3	.03	.03	(.04)	.04	.04	.04	.05	.05
	14	.06	.03	.03	.05	.01	.02	.01	.01
	20	.14	.11	.14	.11	.13	.13	.10	.11
	29	.03	.03	.02	.04	.02	.02	.02	.02

Table 1.--Precipitation, Badger Wash (April 2 to November 11, 1968)

[When numbers are shown in parentheses, no daily record obtained. Amounts estimated from total catch or other records.]

Date	Amount (inches)																			
	Gage number												Watershed number							
	1	2	3	3A	4	5	6	7	7A	8	9	11	1A	1B	2A*	2B*	3A	3B	4A**	4B**
Apr. 2	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	0.18	0.20	0.25	0.21	0.20	0.25	(0.20)	0.20	0.20	0.20	0.20	0.18	0.19	0.22	0.21
3	.13	.14	.17	.15	.10	.13	.17	.11	.15	.20	.13	.20	.13	.13	.13	.15	.13	.14	.16	.17
6	.50	.53	.48	.48	.50	.49	.51	.45	.46	.50	.46	.50	.50	.51	.49	.48	.49	.50	.47	.48
16	.20	.18	.20	.16	.10	.21	.19	.14	.15	.10	.17	.10	.20	.19	.14	.16	.21	.20	.14	.13
17	.19	.20	.09	.16	.10	.20	.22	.10	.14	.20	.08	.20	.19	.19	.14	.16	.20	.21	.14	.16
18	.13	.14	.12	.12	.20	.11	.11	.09	.12	.10	.13	.10	.13	.13	.15	.12	.11	.11	.12	.11
19	.18	.20	.16	.19	.20	.19	.25	.17	.18	.20	.25	.20	.18	.19	.19	.19	.19	.21	.20	.19
21	0	0	0	0	0	0	0	0	0	0	0	.10	0	0	0	0	0	0	0	0
26	.07	.08	.02	.04	(.03)	.03	.06	.03	(.04)	(.05)	.03	.05	.07	.07	.04	.04	.03	.04	.04	.04
27	.02	.03	.04	.03	(.03)	.04	.02	.02	(.02)	(.03)	.03	.15	.02	.02	.03	.03	.04	.03	.02	.02
May 5	.03	.10	.05	.06	.06	.05	.05	.03	.05	(.05)	.04	(.04)	.03	.06	.06	.06	.05	.05	.05	.05
6	.09	.14	.12	.10	.14	.08	.11	.08	.09	.15	.12	(.08)	.09	.11	.11	.10	.08	.09	.11	.11
11	.02	.03	0	0	0	.04	.05	0	.03	0	.05	(.05)	.02	.02	0	0	.04	.04	.03	.02
12	.20	.23	.24	.23	.40	.21	.21	.22	.23	.30	.18	.20	.20	.21	.28	.23	.21	.21	.24	.26
13	.11	.16	.16	.14	.10	.18	.25	.25	.26	.30	.24	.30	.11	.13	.13	.14	.18	.20	.27	.28
24	.05	.07	.05	.05	.10	(.10)	.10	.16	.20	.20	.19	.10	.05	.06	.07	.05	.10	.10	.20	.20
June 7	.11	.12	.06	.08	(.07)	.07	.08	.10	.09	.10	.06	.10	.11	.11	.08	.08	.07	.07	.09	.09
July 5	0	.04	(.04)	.04	(.04)	.05	.02	0	.09	(.07)	0	0	0	.02	.04	.04	.05	.04	.07	.08
22	0	0	0	.01	0	0	0	0	.02	(.02)	.01	0	0	0	.01	.01	0	0	.02	.02
23	0	.02	0	.05	(.04)	0	0	0	.01	(.02)	.01	0	0	.01	.05	.05	0	0	.01	.01
24	.05	.06	.11	.04	(.04)	.05	.05	.02	.08	.10	.06	.10	.05	.05	.04	.04	.05	.05	.08	.09
25	0	0	0	.02	0	0	0	0	.01	0	0	.10	0	0	.01	.02	0	0	.01	.01
26	1.51	1.53	1.49	1.20	1.10	1.39	1.28	1.06	1.14	1.10	1.06	1.10	1.51	1.52	1.17	1.20	1.39	1.36	1.12	1.12
27	1.05	.90	.71	.80	.30	.98	.72	.46	.49	.60	.43	(.20)	1.05	.98	.64	.80	.98	.91	.50	.53
30	0	.08	0	.03	0	0	0	0	.03	0	0	0	0	.04	.02	.03	0	0	.02	.02
Aug. 2	.85	.81	.93	1.04	1.10	.74	.81	.84	.93	1.00	.95	(.70)	.85	.83	1.06	1.04	.74	.76	.95	.96
7	.16	.22	.14	.28	(.10)	.07	.12	.15	.21	.10	.05	(.06)	.16	.19	.22	.28	.07	.08	.16	.17
9	.10	.10	.15	(.15)	.10	.07	.13	.04	.10	.10	0	(.05)	.10	.10	.13	.15	.07	.09	.08	.10
13	.34	.40	(.25)	(.30)	(.40)	.16	.20	.15	.22	(.20)	.23	(.20)	.34	.37	.33	.30	.16	.17	.22	.21
14	.91	1.05	(.70)	(.80)	(.50)	.88	.90	.82	(.87)	(.90)	.83	(.70)	.91	.98	.70	.80	.88	.89	.87	.88
15	0	0	0	.01	0	0	0	0	0	0	0	0	0	0	.01	.01	0	0	0	0
17	0	0	0	0	0	0	0	0	.01	0	0	0	0	0	0	0	0	0	.01	.01
22	.02	0	0	.02	0	0	0	0	.03	0	0	0	.02	.01	.01	.02	0	0	.02	.02
28	.11	.16	(.50)	.61	.60	.12	.19	.23	.31	.30	.29	.40	.11	.13	.61	.61	.12	.14	.30	.31
Sept. 3	.03	.03	(.04)	.04	(.04)	.04	.05	.04	.05	(.05)	.03	(.03)	.03	.03	.04	.04	.04	.04	.05	.05
14	.06	.03	.03	.05	(.04)	.01	.03	0	.01	(.02)	0	0	.06	.05	.05	.05	.01	.02	.01	.01
20	.14	.11	.14	.11	.10	.13	.12	.08	.12	.10	.05	.10	.14	.13	.11	.11	.13	.13	.10	.11
29	.03	.03	.02	.04	(.04)	.02	.02	0	.02	(.03)	0	(.02)	.03	.03	.04	.04	.02	.02	.02	.02

er records.]

Date		Watershed number					
	1	A*	2B*	3A	3B	4A**	4B**
Oct. 4	.27	.23	.25	.23	.24	.27	.27
7	.05	.05	.05	.04	.04	.05	.06
8	.09	.10	.10	.05	.05	.07	.08
15	.03		0	.04	.03	.05	.06
16	.02	.07	.05	.01	.01	.02	.02
30	.03	.03	.03	.07	.07	.07	.07
31	.12	.14	.13	.10	.10	.14	.15
Nov. 6	0		.01	0	0	.01	.01
Total Apr. 2-Nov. 11, 1968	8.20	.00	8.45	7.56	7.63	7.80	7.97
Oct. 29, 1967 to Nov. 11, 1968	13.33	--	--	--	--	--	--

* Gage 3A used in computat

** Gage 7A used in computat

Table 1.--Precipitation, Badger Wash (April 2 to November 11, 1968)--Cont.

[When numbers are shown in parentheses, no daily record obtained. Amounts estimated from total catch or other records.]

Date	Amount (inches)																			
	Gage number												Watershed number							
	1	2	3	3A	4	5	6	7	7A	8	9	11	1A	1B	2A*	2B*	3A	3B	4A**	4B**
Oct. 4	.27	.27	.21	.25	.20	.23	.26	.20	.31	.20	.21	.20	.27	.27	.23	.25	.23	.24	.27	.27
7	.05	0	.03	(.05)	(.05)	.04	.04	.03	.03	.10	.04	(.04)	.05	.03	.05	.05	.04	.04	.05	.06
8	.09	.07	.07	(.10)	.10	.05	.05	.04	.07	.10	.05	.10	.09	.08	.10	.10	.05	.05	.07	.08
15	.03	.01	0	0	0	.04	.01	0	.06	(.05)	0	0	.03	.02	0	0	.04	.03	.05	.06
16	.02	.01	.02	(.05)	.10	.01	0	0	.02	(.02)	0	.10	.02	.02	.07	.05	.01	.01	.02	.02
30	.03	.05	.05	.03	.03	.07	.08	.05	.08	(.06)	.05	(.05)	.03	.04	.03	.03	.07	.07	.07	.07
31	.12	.10	.13	.13	.17	.10	.10	.10	.12	.20	.11	.20	.12	.11	.14	.13	.10	.10	.14	.15
Nov. 6	0	0	0	.01	0	0	0	0	.01	0	0	.10	0	0	0	.01	0	0	.01	.01
Total Apr. 2- Nov. 11, 1968	8.20	8.63	7.92	8.45	7.52	7.56	7.76	6.51	7.87	8.12	6.87	7.22	8.20	8.37	9.00	8.45	7.56	7.63	7.80	7.97
Oct. 29, 1967 to Nov. 11, 1968	13.33	14.04	12.86	--	--	13.11	12.92	10.77	--	--	11.70	--	--	--	--	--	--	--	--	--

* Gage 3A used in computations for watersheds 2A and 2B

** Gage 7A used in computations for watersheds 4A and 4B.

Table 2.--Runoff at Badger Wash, 1968

Drainage basin	Drainage area (sq mi)	Runoff		Sediment	
		Acre-ft	Acre-ft per sq mile	Acre-ft	Acre-ft per sq mile
1-A Grazed	0.066	8.58	130.0	0.52	7.88
1-B	.084	9.86	117.4	.62	7.38
2-A	.148 1/	13.16	88.9	.97	6.55
Fenced 2-B 1968	.158	14.06	89.0	.98	6.20
3-A Grazed	.059	7.03	119.2	.47	7.97
3-B	.048	5.32	110.8	.47	9.79
4-A	.022	1.67	75.9	.14	6.36
Fenced 4-B 1968	.019	1.59	83.7	.07	3.68
5	.055	7.70	140.0	.40	7.27
6	.220	23.46	106.6	1.82	8.27
7	.094	12.87	136.9	1.05	11.17
8	.109	13.19	121.0	.53	4.86
9	.313	20.15	64.4	.38	1.21
10	.100	7.34	73.4	.17	1.70
11	.089	8.68	97.5	.30	3.37
12	.092	9.42	102.4	*	*
13	.484	31.95	66.0	4.93	10.19
14	1.53	149.2	97.5	5.62	3.67
15	.136 2/	3.01	22.1	.02	.15
16	.239 2/	2.11	8.83	.02	.08

1/ Excluding runoff from auxiliary watershed.

2/ Drainage area approximate. To be computed at a later date.

* Not determined.

Table 3.--Runoff, Badger Wash Observation Reservoir 1A

Location.--Lat 39°20', long 108°56', in sec. 24, T. 8 S., R. 104 W., near Mack, Mesa Co., Colo.

Drainage area.--0.066 sq mi (42 acres).

Records available.--April 1954 to November 1968, summer months only.

Gage.--Water-stage recorder. Elevation of gage 5,058.08 ft above mean sea level.

Runoff and discharge determination.--Contents of reservoir and volume of inflow computed from a stage-capacity curve of the reservoir.

Maxima.--Maximum storm inflow 3.27 acre-ft, 49.5 acre-ft per sq mile, July 25, 1955.

Remarks.--Records good.

Capacities.--At spillway level (gage-ht of 54.7 ft):
December 1953 - 8.10 acre ft
July 1955, November 1956 - 7.39 acre-ft
October 1957, November 1958 - 7.15 acre-ft
November 1959 - 6.86 acre-ft
November 1961 - 6.50 acre-ft
November 1962 - 6.42 acre-ft
November 1963 - 6.37 acre-ft
November 1964 - 6.33 acre-ft
November 1965 - 5.88 acre-ft
November 1966 - 5.88 acre-ft
November 1967 - 5.72 acre-ft
November 1968 - 5.20 acre-ft

Table on next page.

Watershed 1A, Storm runoff, April 2 to November 11, 1968

Date	Precipitation (inches)	Inflow		
		Acre-ft	Acre-ft per sq mile	inches
July 26	1.51	2.72	41.21	0.773
July 27	1.05	2.56	38.79	.727
Aug. 2	.85	.60	9.09	.170
Aug. 7	.16	.03	.45	.008
Aug. 13	.34	.75	11.36	.213
Aug. 14	.91	1.90	28.79	.540
Oct. 4	.27	.02	.30	.006
Total	--	8.58	129.99	2.437

Table 3.--Runoff, Badger Wash--Continued
Observation Reservoir 1B

Location.--Lat 39°20', long 108°56', in sec. 25, T. 8 S., R. 104 W., near Mack, Mesa Co., Colo.

Drainage area.--0.084 sq mi (54 acres).

Records available.--April 1954 to November 1968, summer months only.

Gage.--Water-stage recorder. Elevation of gage is 5,023.92 ft above mean sea level.

Runoff and discharge determinations.--Contents of reservoir and volume of inflow computed from a stage-capacity curve of the reservoir.

Maxima.--Maximum storm inflow volume 3.46 acre-ft, 41.2 acre-ft per sq mile, July 26, 1968.

Remarks.--Records good.

Capacities.--At spillway level (gage-ht of 19.5 ft):
December 1953 - 19.8 acre-ft
July 1955, November 1956 - 19.2 acre-ft
October 1957, November 1958, November 1959 - 19.1 acre-ft
November 1961 - 18.7 acre-ft
November 1962 - 18.6 acre-ft
November 1963 - 18.5 acre-ft
November 1964 - 18.5 acre-ft
November 1965 - 18.2 acre-ft
November 1966 - 18.2 acre-ft
November 1967 - 18.0 acre-ft
November 1968 - 17.4 acre-ft

Table on next page.

Watershed 1B, Storm runoff, April 2 to November 11, 1968

Date	Precipitation (inches)	Inflow		
		Acre-ft	Acre-ft per sq mile	Inches
July 26	1.52	3.46	41.19	0.772
July 27	.98	1.98	23.57	.442
Aug. 2	.83	.74	8.81	.165
Aug. 7	.19	.15	1.79	.034
Aug. 13	.37	.82	9.76	.183
Aug. 14	.98	2.66	31.67	.594
Aug. 28	.13	.02	.24	.004
Oct. 4	.27	.03	.36	.007
Total	--	9.86	117.39	2.201

Table 3.--Runoff, Badger Wash--Continued
Observation Reservoir 2A

Location.--Lat 39°20', long 108°57', in sec. 36, T. 8 S., R. 104 W., near Mack, Mesa Co., Colo.

Drainage area.--0.148 sq mi (95 acres).

Records available.--April 1954 to November 1968, summer months only.

Gage.--Water-stage recorder. Elevation of gage is 4,946,43 ft above mean sea level. Reservoir of side drainage in same watershed equipped with reference mark, crest stages noted. Elevation of reference mark is 4,940 ft (from topographic map).

Runoff and discharge determinations.--Contents of reservoirs and volume of inflow computed from a stage capacity curve of the reservoir.

Maxima.--Maximum storm inflow volume 7.71 acre-ft, 46.2 acre-ft per sq mile, July 25, 1955. Inflow lasted 50 minutes.

Remarks.--Records good.

Capacities.--At spillway level.

Main reservoir

Dec. 1953 - 6.34 acre-ft
July 1955, Nov. 1956 - 4.42 acre-ft
Oct. 1957, Nov. 1958 - 3.93 acre-ft
Nov. 1959 - 3.72 acre-ft
Dam raised Nov. 1959
Nov. 1959 - 15.08 acre-ft
Nov. 1961 - 13.86 acre-ft
Nov. 1962 - 13.70 acre-ft
Nov. 1963 - 13.53 acre-ft
Nov. 1964 - 12.40 acre-ft
Nov. 1965 - 12.07 acre-ft
Nov. 1966 - 12.07 acre-ft
Nov. 1967 - 11.49 acre-ft
Nov. 1968 - 10.52 acre-ft

Auxiliary reservoir

Dec. 1953 - 6.14 acre-ft
July 1955, Nov. 1956, Oct. 1957, Nov. 1958 - 5.71 acre-ft
Nov. 1959 - 5.61 acre-ft
July 1962 - 5.55 acre-ft
Nov. 1963 - 5.49 acre-ft
Nov. 1964 - 5.31 acre-ft
Nov. 1965 - 5.18 acre-ft
Nov. 1966 - 5.18 acre-ft
Nov. 1967 - 5.24 acre-ft
Nov. 1968 - 4.98 acre-ft

Table on next page.

Watershed 2A, Storm runoff, April 2 to November 11, 1968

Date	Precipitation (inches)	Inflow		
		Acre-ft	Acre-ft per sq mile	Inches
uly 26	1.17	3.61	24.39	0.457
uly 27	.64	2.07	13.99	.262
ug. 2	1.06	1.73	11.69	.219
ug. 7	.22	.28	1.89	.035
ug. 13	.33	.38	2.57	.048
ug. 14	.70	2.68	18.11	.340
ug. 28	.61	2.39	16.15	.303
ct. 4	.23	.01	.07	.001
ct. 31	.14	.01	.07	.001
Total	--	13.16	88.93	1.666

Table 3.--Runoff, Badger Wash--Continued
Observation Reservoir 2B

Location.--Lat 39°20', long 108°57', in sec. 25, T. 8 S., R. 104 W., near Mack, Mesa Co., Colo.

Drainage area.--0.158 sq mi (101 acres).

Records available.--April 1954 to November 1968, summer months only.

Gage.--Water-stage recorder. Elevation of gage is 4,970 ft above mean sea level.

Runoff and discharge determinations.--Contents of reservoir and volume of inflow computed from a stage capacity curve of the reservoir.

Maxima.--Maximum storm inflow volume 6.29 acre-ft, 39.8 acre-ft per sq mile, July 25, 1955. Inflow lasted 90 minutes.

Remarks.--Records good.

Capacities.--At spillway level.
December 1953 - 8.45 acre-ft
July 1955, November 1956, October 1957, November 1958 - 6.05 acre-ft
Dam raised
June 1959 - 24.8 acre-ft
November 1959 - 24.5 acre-ft
November 1961 - 23.8 acre-ft
November 1962 - 23.6 acre-ft
November 1963 - 23.5 acre-ft
November 1964 - 23.0 acre-ft
November 1965 - 22.7 acre-ft
November 1966 - 22.7 acre-ft
November 1967 - 22.3 acre-ft
November 1968 - 21.3 acre-ft

Table on next page.

Watershed 2B, Storm runoff, April 2 to November 11, 1968

Date	Precipitation (inches)	Inflow		
		Acre-ft	Acre-ft per sq mile	Inches
uly 26	1.20	5.01	31.71	0.594
uly 27	.80	1.81	11.46	.215
ug. 2	1.04	1.78	11.27	.211
ug. 7	.28	.48	3.04	.057
ug. 13	.30	.69	4.37	.082
ug. 14	.80	2.81	17.78	.333
ug. 28	.61	1.44	9.11	.171
ct. 4	.25	.02	.13	.002
ct. 31	.13	.02	.13	.002
Total	--	14.06	89.00	1.667

Table 3.--Runoff, Badger Wash--Continued
Observation Reservoir 3A

Location.--Lat 39°20', long 108°56', in sec. 25, T. 8 S., R. 104 W., near Mack, Mesa Co., Colo.

Drainage area.--0.059 sq mi (38 acres).

Records available.--April 1954 to November 1968, summer months only.

Gage.--Water-stage recorder. Elevation of gage 5,033.68 ft above mean sea level.

Runoff and discharge computations.--Contents of reservoir and volume of inflow computed from a stage capacity curve of the reservoir.

Maxima.--Maximum storm inflow volume 2.98 acre-ft, 50.5 acre-ft per sq mile, July 25, 1955.

Remarks.--Records good.

Capacities.--At spillway level.
December 1956 - 12.90 acre-ft
July 1955, November 1956 - 12.63 acre-ft
October 1957, November 1958 - 12.53 acre-ft
November 1959 - 12.32 acre-ft
November 1961 - 12.12 acre-ft
November 1962 - 12.03 acre-ft
November 1963 - 12.00 acre-ft
November 1964 - 11.97 acre-ft
November 1965 - 11.53 acre-ft
November 1966 - 11.53 acre-ft
November 1967 - 11.33 acre-ft
November 1968 - 10.86 acre-ft

Table on next page.

Watershed 3A, Storm runoff, April 2 to November 11, 1968

Date	Precipitation (inches)	Inflow		
		Acre-ft	Acre-ft per sq mile	Inches
Apr. 3	0.13	0.01	0.17	0.003
Apr. 6	.49	.02	.34	.006
July 26	1.39	2.14	36.27	.680
July 27	.98	2.50	42.37	.794
Aug. 2	.74	.38	6.44	.121
Aug. 13	.16	.06	1.02	.019
Aug. 14	.88	1.88	31.86	.597
Oct. 4	.23	.03	.51	.010
Oct. 31	.10	.01	.17	.003
Total	--	7.03	119.15	2.233

Table 3.--Runoff, Badger Wash--Continued
Observation Reservoir 3B

Location.--Lat 39°20', long 108°56', in sec. 25, T. 8 S., R. 104 W., near Mack, Mesa Co., Colo.

Drainage area.--0.048 sq mi (31 acres).

Records available.--April 1954 to November 1968, summer months only.

Gage.--Water-stage recorder. Elevation of gage is 5,013.80 ft above mean sea level.

Runoff and discharge determinations.--Contents of reservoir and volume of inflow computed from a stage capacity curve of the reservoir.

Maxima.--Maximum storm runoff volume 2.35 acre-ft, 49.6 acre-ft per sq mile, July 25, 1955.

Remarks.--Records good.

Capacities.--At spillway level.
December 1953 - 8.10 acre-ft
July 1955, November 1956 - 7.69 acre-ft
October 1957, November 1958 - 7.65 acre-ft
November 1959 - 7.52 acre-ft
November 1961 - 7.38 acre-ft
November 1962 - 7.16 acre-ft
November 1963 - 6.99 acre-ft
November 1964 - 6.97 acre-ft
November 1965 - 6.74 acre-ft
November 1966 - 6.74 acre-ft
November 1967 - 6.47 acre-ft
November 1968 - 6.00 acre-ft

Table on next page.

Watershed 3B, Storm runoff, April 2 to November 11, 1968

Date	Precipitation (inches)	Inflow		
		Acre-ft	Acre-ft per sq mile	Inches
Apr. 2	0.19	0.01	0.21	0.004
Apr. 6	.50	.02	.42	.008
May 13	.20	.01	.21	.004
July 26	1.36	1.79	37.29	.699
July 27	.91	1.38	28.75	.539
Aug. 2	.76	.36	7.50	.141
Aug. 7	.08	.02	.42	.008
Aug. 13	.17	.05	1.04	.020
Aug. 14	.89	1.65	34.38	.645
Aug. 28	.14	.01	.21	.004
Oct. 4	.24	.01	.21	.004
Oct. 31	.10	.01	.21	.004
Total	--	5.32	110.85	2.080

Table 3.--Runoff, Badger Wash--Continued
Observation Reservoir 4A

Location.--Lat 39°19', long 108°56', sec. 36, T. 8 S., R. 104 W., near Mack, Mesa Co., Colo.

Drainage area.--0.022 sq mi (14 acres).

Records available.--April 1954 to November 1968, summer months only.

Gage.--Water-stage recorder. Elevation of reference mark is 4,944.83 ft above mean sea level.

Runoff and discharge determinations.--Contents of reservoir and volume of inflow computed from a stage-capacity curve of the reservoir.

Maxima.--Maximum storm inflow volume, 1.20 acre-ft, 54.5 acre-ft per sq mi, July 25, 1955. Inflow lasted 45 minutes.

Remarks.--Records good.

Capacities.--At spillway level.
December 1953 - 3.05 acre-ft
July 1955, November 1956 - 2.60 acre-ft
October 1957, November 1958 - 2.39 acre-ft
November 1959 - 2.33 acre-ft
November 1961, November 1962 - 2.10 acre-ft
November 1963 - 2.05 acre-ft
November 1964 - 1.90 acre-ft
November 1965 - 1.72 acre-ft
November 1966 - 1.72 acre-ft
November 1967 - 1.61 acre-ft
November 1968 - 1.47 acre-ft

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Watershed 4A, Storm runoff, April 2 to November 11, 1968

Date	Precipitation (inches)	Inflow		
		Acre-ft	Acre-ft per sq mile	Inches
July 26	1.12	0.33	15.00	0.281
July 27	.50	.42	19.09	.358
Aug. 2	.95	.19	8.64	.162
Aug. 7	.16	.01	.45	.008
Aug. 14	.87	.71	32.27	.605
Aug. 28	.30	.01	.45	.008
Total	--	1.67	75.90	1.422

Table 3.--Runoff, Badger Wash--Continued
Observation Reservoir 4B

Location.--Lat 39°19', long 108°56', in sec. 36, T. 8 S., R. 104 W., near Mack, Mesa Co., Colo.

Drainage area.--0.019 sq mi (12 acres).

Records available.--April 1954 to November 1968, summer months only.

Gage.--Water-stage recorder. Elevation of reference mark is 4,969.96 ft above mean sea level.

Runoff and discharge determinations.--Contents of reservoir and volume of inflow computed from a stage-capacity curve of the reservoir.

Maxima.--Maximum inflow 48.0 cfs, 5:45 pm, July 25, 1955. Maximum storm inflow volume 0.77 acre-ft, 40.5 acre-ft per sq mi, July 25, 1955

Remarks.--Records good.

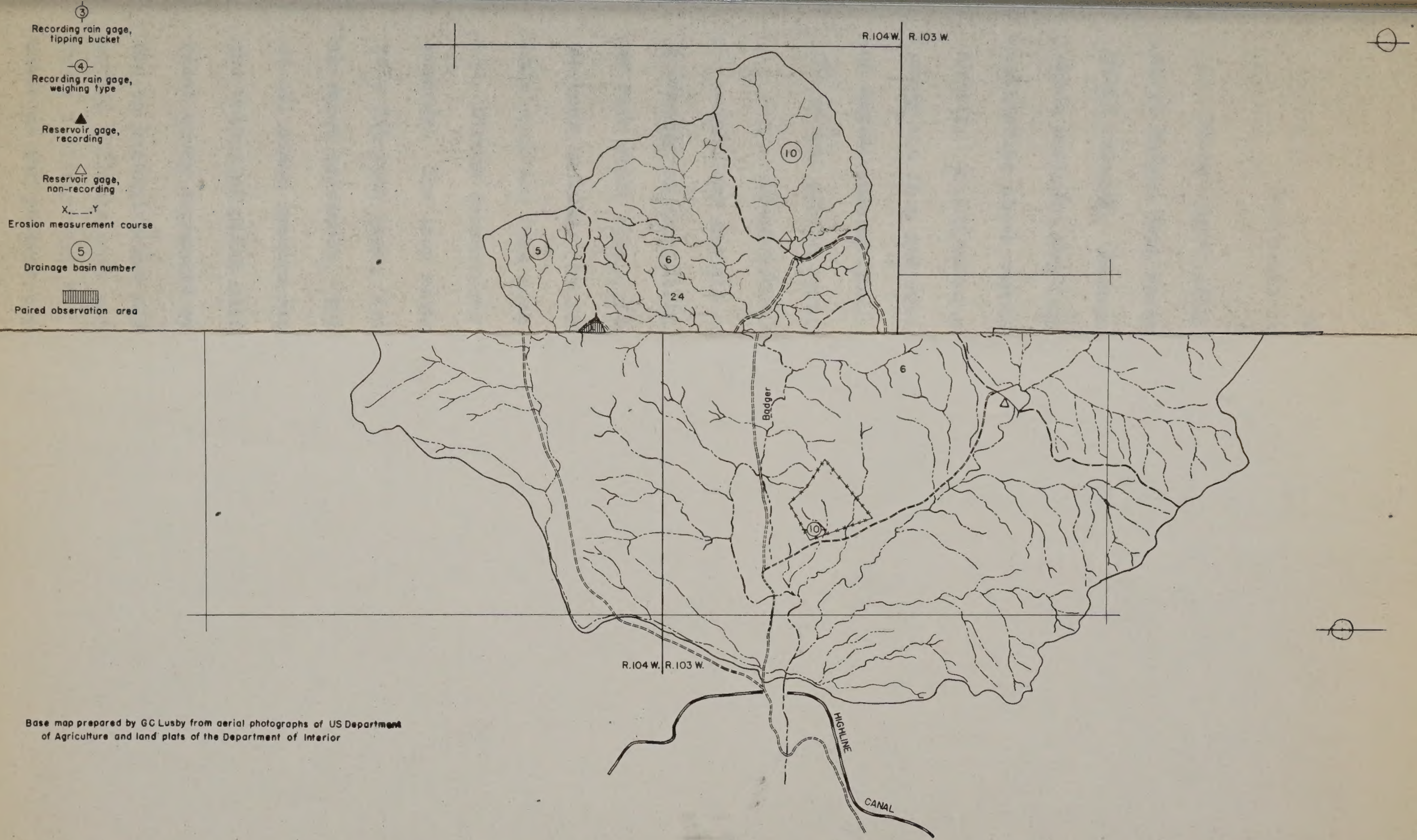
Capacities.--At spillway level.

December 1953 - 4.52 acre-ft
July 1955, November 1956 - 4.24 acre-ft
October 1957, November 1958 - 4.16 acre-ft
November 1959, November 1961 - 4.11 acre-ft
November 1962 - 4.09 acre-ft
November 1963 - 4.05 acre-ft
November 1964 - 3.98 acre-ft
November 1965 - 3.85 acre-ft
November 1966 - 3.85 acre-ft
November 1967 - 3.77 acre-ft
November 1968 - 3.70 acre-ft

Table on next page.

Watershed 4B, Storm runoff, April 2 to November 11, 1968

Date	Precipitation (inches)	Inflow		
		Acre-ft	Acre-ft per sq mile	Inches
July 26	1.12	0.64	33.68	0.632
July 27	.53	.23	12.10	.227
Aug. 2	.96	.13	6.84	.128
Aug. 7	.17	.03	1.58	.030
Aug. 13	.21	.04	2.11	.040
Aug. 14	.88	.45	23.68	.444
Aug. 28	.31	.07	3.68	.069
Total	--	1.59	83.67	1.570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Recording rain gage, tipping bucket
-④-
Recording rain gage, weighing type
Reservoir gage, recording
Reservoir gage, non-recording
X.__.Y
Erosion measurement course
⑤
Drainage basin number
Paired observation area
R.104 W.
R. 103 W.
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Badger
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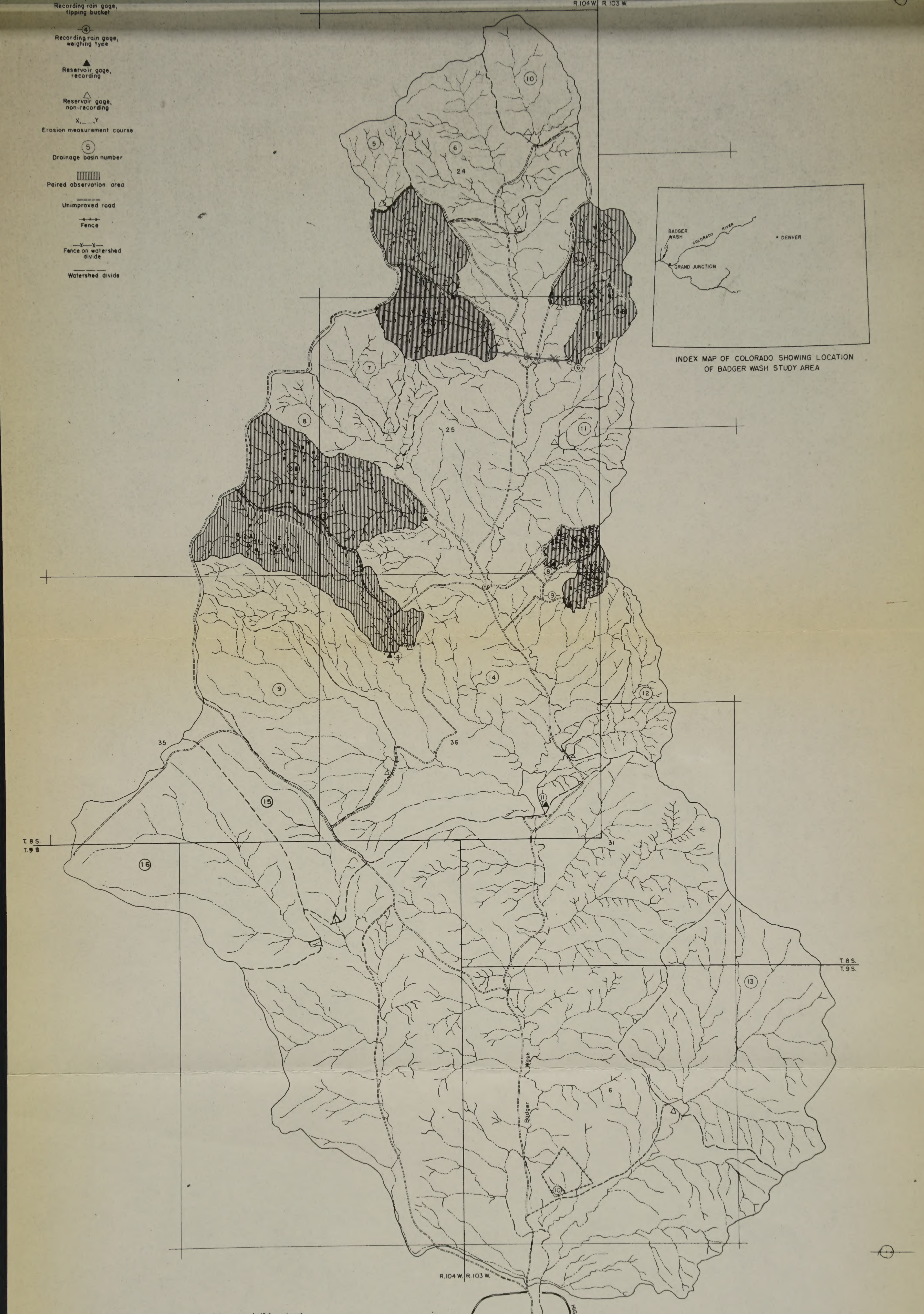
R.104 W.
R. 103 W.
HIGHLINE
CANAL

Base map prepared by G C Lusby from aerial photographs of US Department of Agriculture and land plats of the Department of Interior

MAP OF BADGER WASH COOPERATIVE STUDY AREA, COLORADO, SHOWING HYDROLOGIC NETWORK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Reservoir gage, non-recording
X.__.Y
Erosion measurement course
Drainage basin number
Paired observation area
Unimproved road
Fence
Fence on watershed divide
Watershed divide
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COLORADO RIVER
DENVER
GRAND JUNCTION
T. 8 S.
T. 9 S.
Badger Wash
HIGHLINE CANAL
24
25
35
36
31
6

Base map prepared by G.C.Lusby from aerial photographs of US Department of Agriculture and land plats of the Department of Interior

MAP OF BADGER WASH COOPERATIVE STUDY AREA, COLORADO, SHOWING HYDROLOGIC NETWORK

1/4 0 1 Mile

Badger Wash Progress Report

Watershed cover and forage utilization 1968-1969

by J. Robert Owen

Plant composition and ground cover conditions were sampled in 1968 on 17 Badger Wash watersheds for which there are runoff and sediment yield records. Transect observation methods for the eight paired watersheds included the loop, all contacts, and first contact methods for estimating plant composition and ground cover. Sampling was in late August. Ground cover on nine additional watersheds was sampled in July using the loop and first contact methods. Each watershed was type-mapped on aerial photographs, and transect averages were weighted according to the extent of the type.

Comparisons of the loop and all contacts methods

The loop and all contacts methods were used to observe all vegetation transects on the paired watersheds in 1967 and 1968. The percent composition of bare soil, rock, and litter did not differ significantly between methods in 1967. In 1968, however, the all contacts method measured more bare soil and less rock and litter than did the loop method.

Direct comparisons of plant cover cannot be made between the two methods. The loop method considers the presence of a perennial root crown in a 3/4-inch loop. Aerial portions of shrubs are considered separately as shrub overstory. The all contacts method considers the aerial portion of all plant species along the transect. The all contacts method estimates the volume of plant material, while the loop method estimates plant frequency. Plant cover estimated by the all contacts method reflects yearly differences due to precipitation and grazing use. Plant cover estimated by the loop method reflects only major changes in composition and abundance over time. Table 1 illustrates the comparison of measuring basal cover versus aerial cover on the percent composition of plant catagories by the two methods.

Aerial coverage of shrubs are estimated by both methods so that a direct comparison is possible. Both methods estimate the percent composition of nuttall saltbush, little rabbitbrush, and snakeweed within one percent of the other. The estimate for shadscale is 5 percent higher by the loop method, but this is not a statistically significant difference. These four species account for 85 percent of the shrub species at Badger Wash.

Percent composition of galleta grass within the grass category is 63 percent by the all contacts method and 70 percent by the loop method. This difference is not significant. Forbs and annuals were not compared because of their great variety and low composition percentages.

Although percent composition differences within plant categories are not large, the loop method results in a higher percent composition for the more numerous species (shadscale and galleta grass). The all contacts method, on the other hand, places slightly more emphasis on the less numerous species. An average of 20 species per basin were detected by the loop method, while the all contacts method detected an average of 26 species per basin.

Seasonal effects of grazing

Eight periods (four spring, four fall) of observations at Badger Wash indicate that ground cover composition (bare, rock, etc.) differences between grazed and nongrazed watersheds are greater in the spring than in the fall. Differences in percent bare soil and percent rock on grazed watersheds are greater between seasons than between years within seasons. Nongrazed watersheds show little difference in the composition of ground cover either between seasons or between years. Spring estimates of percent bare soil correlate best with average annual runoff.

Table 1--Percent composition of plant types as estimated by the loop and all contacts methods

Plant type	All contacts	Loop basal hits	Loop shrub overstory plus basal herbaceous
Grass	37.8	40.9	11.4
Shrub	42.9	24.0	78.8
Forb	6.5	12.6	3.5
Annuals	12.6	22.2	6.2

Seasonal differences in bare soil and rock may best account for the differences in runoff and sediment yields due to grazing at Badger Wash. Plant cover and composition may be important only as it influences the amount of bare soil. In order to test this hypothesis loop observations of ground cover composition will be made on a seasonal basis on two grazed and two nongrazed watersheds. Soil disturbance is greatest immediately following grazing, therefore, this will be the first observation time. Early spring should best reflect the action of frost heave and soil swelling on ground cover. The third observation time will be in the fall after summer rains have had a chance to reexpose covered rock particles. In addition, observations will be made following any major storm event that produces a significant amount of runoff and sediment.

The annual inventory of plant and ground cover by the all contacts method will be changed to spring in order to obtain a better expression of differences due to grazing.

Percent bare soil-runoff relationship

There is a highly significant correlation between the percentage of bare soil and average annual runoff for the 17 watersheds in Badger Wash basin (Branson, Owen; report in progress). Bare soil values for these watersheds range from 41 percent to 81 percent, and the 15-year average annual runoff ranges from 18.5 acre-feet per square mile to 54.0 acre-feet per square mile (fig. 1). The regression line developed for this relationship should give reasonable estimates of annual runoff from small watersheds with similar vegetation and precipitation on Mancos Shale areas. Preliminary investigations show that bare soil is related to runoff in other vegetation and climatic types, but there are different regression curves for each of these plant-soil-climatic areas.

Forage utilization

Sheep grazed the study area for the 16-day period of November 26 to December 12, 1968. Use was by 774 ewes, which resulted in a stocking rate of 30.3 sheep days per acre. That was higher than usual for Badger Wash, but was possible because of the excellent growth conditions resulting from above average precipitation for the previous 12 months. Average weighted use for the study area based on records from Upper Hanks and Oilwell watersheds was 22.7 percent. The animals concentrated mainly on the shadscale-galleta grass type during the winter 1968 grazing season. This was in contrast to the previous seasons use (March 1968) when the nuttall saltbush types received the most use. Changing the grazing season probably accounted for the difference in preference. This is an undesirable situation because without grazing on the study watersheds (Upper Hanks and Oilwell) the effects of grazing on runoff and sediment yield cannot be evaluated. Supplemental feeding to encourage even distribution of the animals or greater efforts by the herder to move the animals to ungrazed areas may solve the problem. Utilization summaries by watershed and by species are in the appendix.

Summary--Composition of ground cover by the all contacts method

Cover	Year	Watershed							
		1A	1B	2A	2B	3A	3B	4A	4B
Bare soil	1967	60	66	66	51	68	79	59	52
	1968	53	59	65	51	72	73	58	60
Rock	1967	14	12	11	18	12	4	29	33
	1968	21	15	14	23	10	5	31	28
Bare and Rock	1967	74	78	77	69	80	83	88	85
	1968	74	74	79	74	82	78	89	88
Litter	1967	26	22	23	31	20	17	12	15
	1968	26	26	21	26	19	22	11	12
Standing litter	1967	3	5	4	4	--	1	1	1
	1968	6	3	9	4	2	2	1	3
Hits on live plants/transect	1967	32	25	31	23	22	16	17	20
	1968								

Summary--Composition of ground cover on
paired basins, August-September 1968
loop method

Cover	Watershed							
	1A	1B	2A	2B	3A	3B	4A	4B
Bare soil	42	51	52	39	67	71	47	40
Rock	27	20	18	30	14	7	41	42
Bare and Rock	69	71	70	70	80	77	88	82
Litter and moss	26	26	24	26	17	21	9	15
Plant density index	6	3	6	4	2	2	3	3
Shrub overstory	14	17	9	14	14	16	11	11
Ground cover index	35	33	32	35	25	27	17	22
Annuals	2	1	3	1	Tr	Tr	Tr	Tr

Summary--Composition of ground cover

basins 5-13, July 1968

Loop method

Cover	Watershed								
	5	6	7	8	9	10	11	12	13
Bare soil	41	52	56	60	68	56	81	76	64
Rock	24	7	11	14	9	6	--	7	15
Bare and rock	65	59	67	74	77	62	81	83	79
Litter and moss	31	33	27	21	18	34	16	14	18
Plant density index	3	7	6	5	5	4	2	3	3
Shrub overstory	15	13	11	8	12	12	19	13	7
Ground cover index	37	45	35	29	26	40	24	23	23
Annual plants	4	5	7	5	2	7	--	2	4

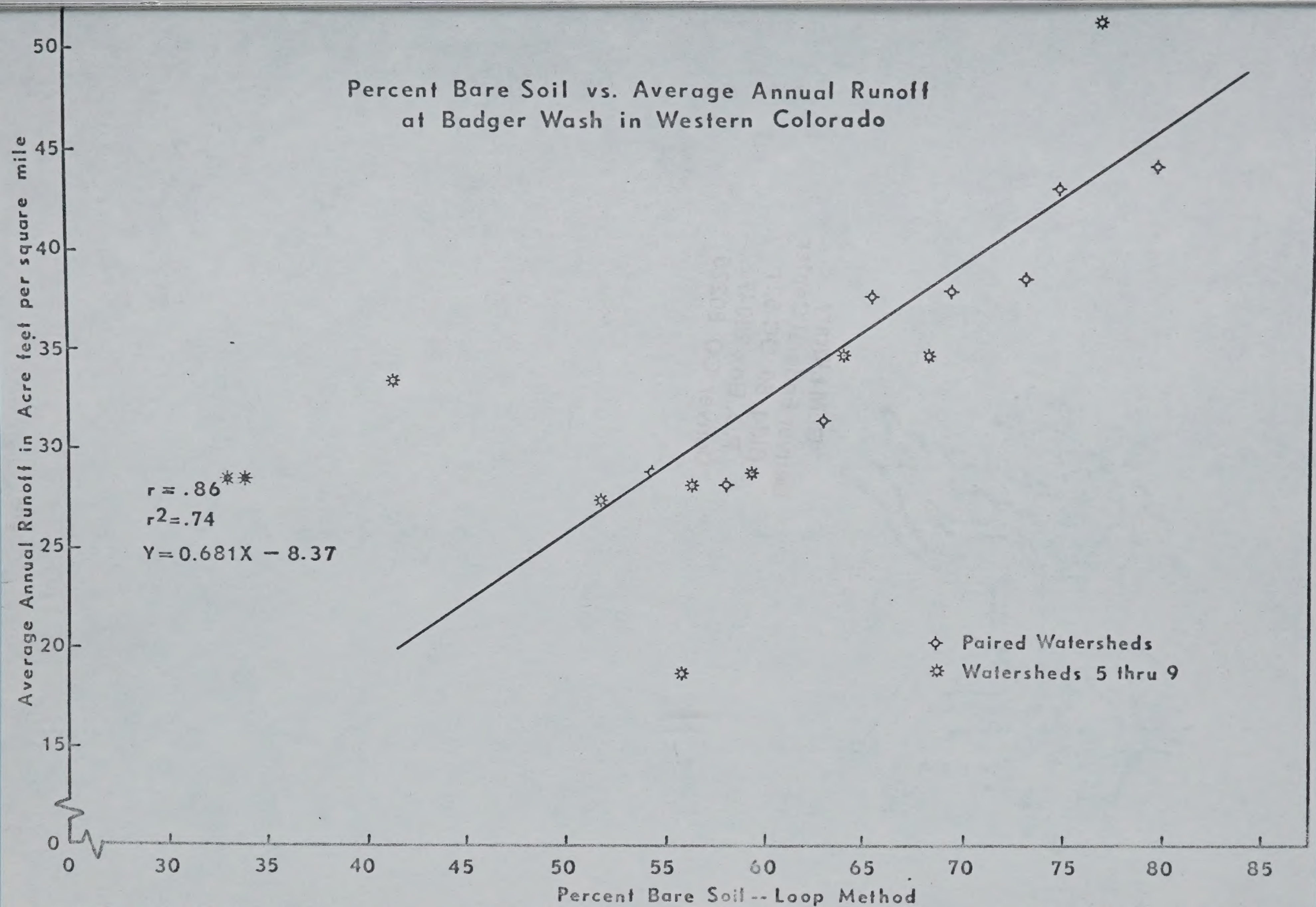
Summary--Composition of ground cover on basins 5-13, July 1968

First contact method

Cover	Watershed								
	5	6	7	8	9	10	11	12	13
Bare soil	32	32	27	39	50	29	62	58	40
Rock	23	11	13	16	11	6	1	9	19
Bare and rock	55	43	40	55	61	35	63	67	59
Litter and moss	18	22	34	20	18	26	14	16	22
Grasses and forbs	7	14	12	13	10	17	7	6	12
Shrub overstory	12	11	8	7	9	10	14	10	5
Annuals	7	9	9	5	2	10	1	2	3

Summary of utilization and frequency of occurrence--December 1968

Species	Upper Hanks-1A		Oil Well-3A	
	Utilization	Frequency percent	Utilization	Frequency percent
Grasses				
Elymus salinus	62	29	42	17
Hilaria jamesii	24	79	30	62
Oryzopsis hymenoides	20	42	22	29
Sitanion hystrix	16	62	19	21
Sporobolus cryptandrus	44	17	--	--
Shrubs				
Artemisia spinescens	10	8	20	4
Artemisia tridentata	39	38	40	4
Atriplex confertifolia	20	100	9	71
Atriplex corrugata	--	--	4	12
Atriplex nuttallii	--	--	8	62
Chrysothamnus greenii	54	54	36	71
Ephedra torreyana	5	4	70	4
Eurotia lanata	65	8	--	--
Gutierrezia sarothrae	17	62	2	54
Opuntia	0	42	0	4
Mamillaria	0	4	--	--
Tetradymia spinosa	0	8	0	42
Forbs				
Aster arenosus	65	46	0	4
Aster venustus	80	4	23	62
Astragalus confertiflorus	0	4	0	8
Astragalus missouriensis	28	25		--
Erigeron spp.	58	29	--	--
Eriogonum bicolor	--	--	27	12
Eriogonum ovalifolium	18	8	5	4
Lepidium montanus	6	25	--	--
Penstemon moffatii	--	--	5	4
Phlox longifolia	50	8	0	4
Sphaeralcea coccinea	58	67	13	12
Stanleya pinnata	--	--	20	4
Unknown forbs	48	21	0	4



Percent Bare Soil vs. Average Annual Runoff at Badger Wash in Western Colorado

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